PROGRAMMED FOR HEALTH

- DESK-TOP DOCTOR
- ROBOT SURGERY
- BODY IMAGING

THE EXPERT DOCTOR SYSTEM is the electronic doctor of the future. It can ask you how you feel, diagnose your illness and tell you which medicine to take – all on a small computer screen.

Although it may never replace the family doctor, the computer has an important part to play in medicine of the future. Although these 'expert doctor systems' have to be developed on large machines, they can be used on small, personal computers in the home or in the doctor's waiting room.

'Interviewing' of patients by computer can save a great deal of the doctor's time. Instead of the doctor quizzing the patient, the patient can 'talk' to the computer, which then makes a diagnosis and suggests an appropriate treatment.

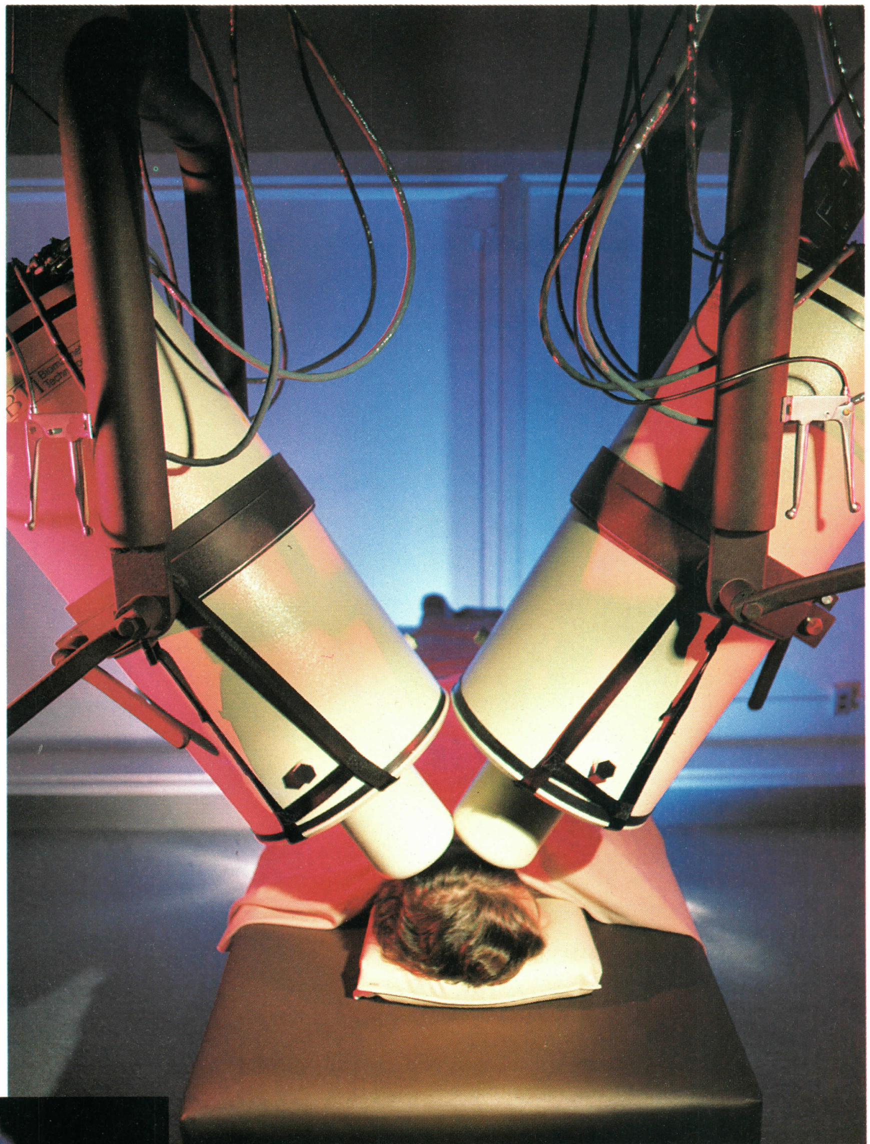
VDU confession

When the idea of interviewing patients by computer was first put forward, it was thought that some people wouldn't want to co-operate with a computer and would be put off by it. In fact, many people actually prefer the computer to the doctor! Alcoholics, for example, tell the computer they drink more than they will admit to their doctor.

Robots are being developed to help in delicate operations. These robots must not only be 'intelligent', they must also be precise. A robot connected to a scanning system will be able to locate a tumour very accurately and guide the surgeon to exactly the right place. This very accurate 'keyhole surgery' means that damage to surrounding tissue will be reduced, and the patient will only carry as small a scar as possible.

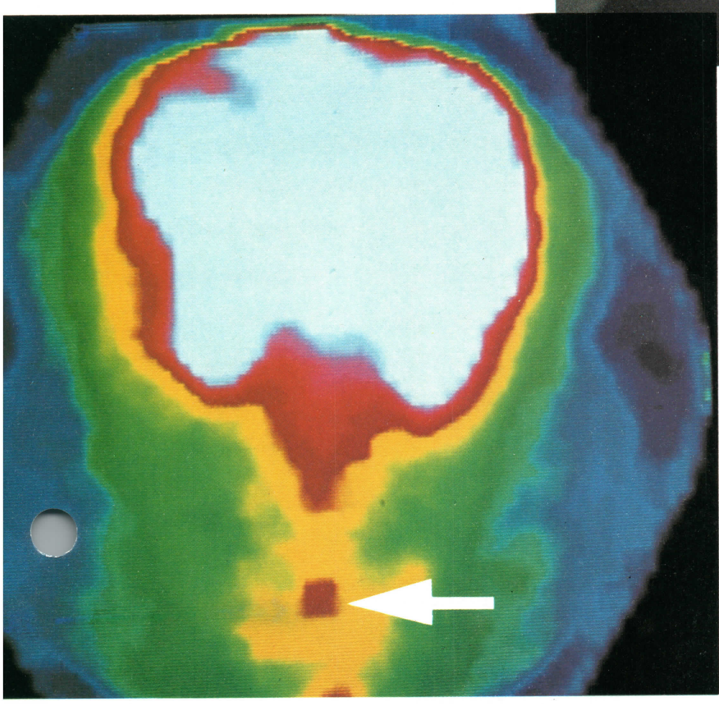
Radiation beam

At present, cancer is treated using drugs, radiation, surgery and lasers – with some success. Much interest is now being directed towards proton beams as a form of cancer therapy. Protons are electrically charged particles present in the nuclei of atoms. They are used as a safe alternative to large doses of radiation therapy.



Hank Morgan/Rainbow

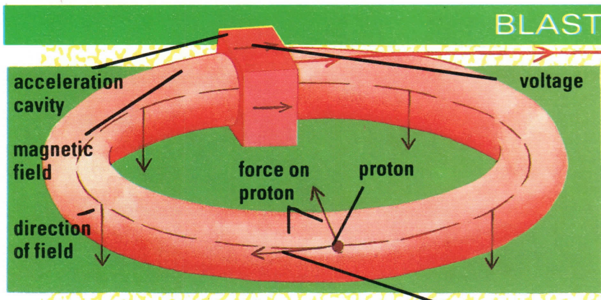
***SQUID** imaging systems are so sensitive they can detect the brain's magnetic field from outside the skull. This painless process gives a 3-D image of the brain for analysis.*

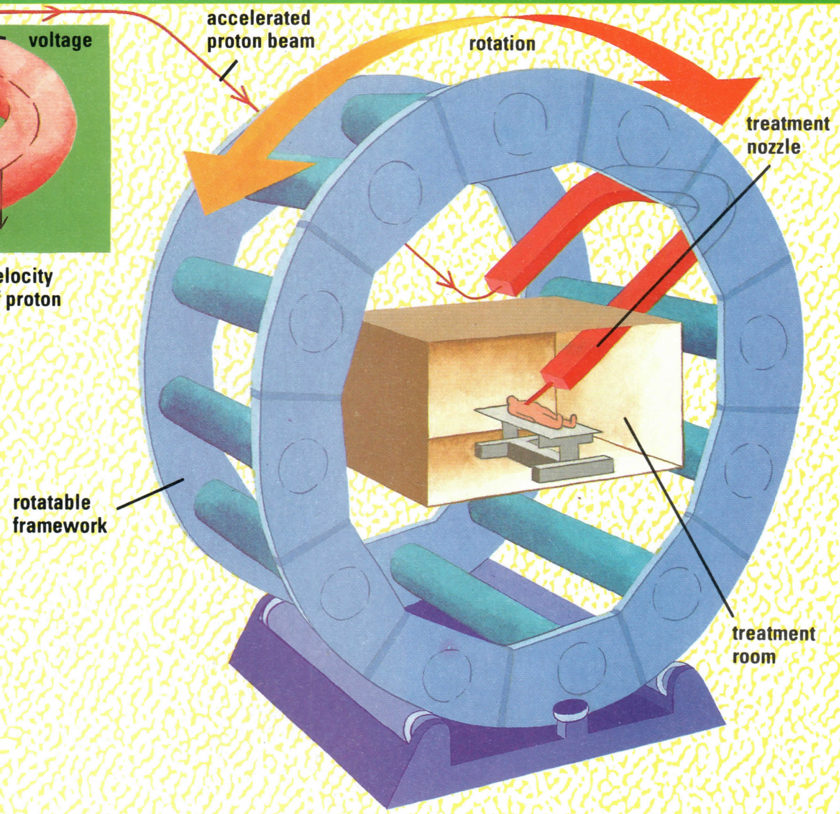


Gamma/Frank Spooner Pictures

***A tiny tumour** in the ovary, picked up by a gamma-ray camera. Radioactive substances called tracers injected into the patient, are carried around the body by the bloodstream, and 'brand' the tumour as a red spot in the on-screen image (arrowed).*

BLASTING TUMOURS WITH HIGH-SPEED PROTONS





Proton accelerators – vast machines that create fast-moving streams of protons (electrically charged sub-atomic particles) – are at the forefront of cancer therapy. The patient lies inside an enormous Ferris wheel that can direct the nozzle of the proton accelerator at any point on the body. The nozzle is only the very end of the accelerator system (above). Powerful super-magnets create an intense magnetic field that drives the protons faster and faster until they reach a critical speed, when they are diverted out of the acceleration tube down the beam line into the nozzle. Under the concentrated proton beam, the tumour breaks up and is excreted from the body. The depth of the beam into the body can be varied to within a few millimeters.

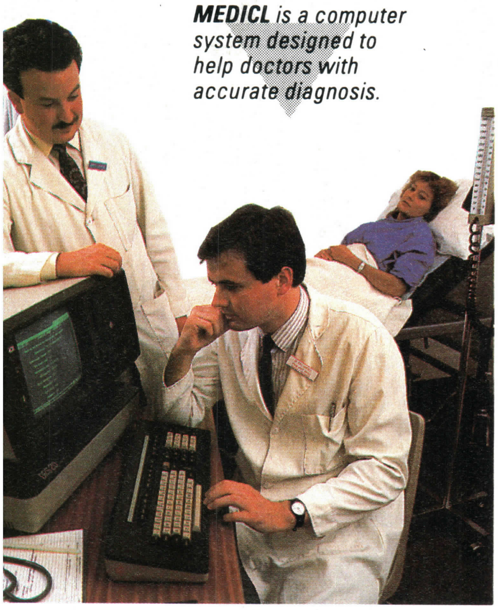
Caroline Brodie

Normal radiation therapy – bathing the tumour in radiation from a radioisotope to break it down – has the side-effect of damaging healthy tissue around the tumour. The advantage of using protons is that they can be sharply focussed to deliver the maximum dose of radiation to the tumour, while not harming tissue in front of or behind it.

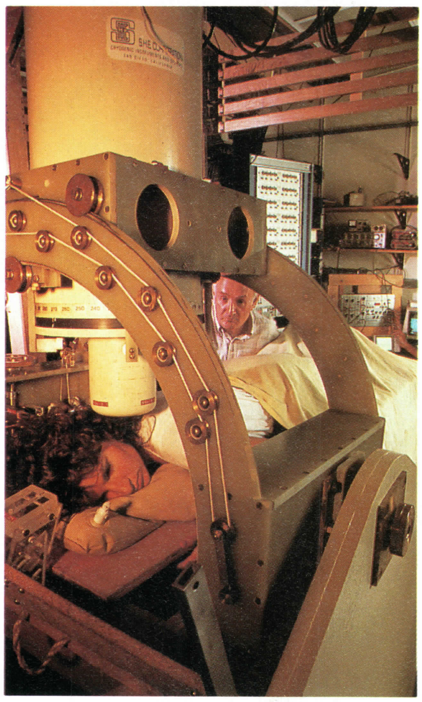
Mapping the body

Machines known as MRIs or Magnetic Resonance Imaging systems make electronic 'maps' of internal areas of the body. This technique is very useful in detecting otherwise unseen diseases. A disease called osteoporosis, in which the bones become brittle and break very easily, is difficult to diagnose without imaging systems.

__MEDICL__ is a computer system designed to help doctors with accurate diagnosis.



CISU, University of Leeds/ICL (UK) Ltd



James Prince/SPL

Quantum leap

However, newer and more advanced machines for imaging are being developed. These machines, called Super-conducting Quantum Interference Devices, or SQUIDs, are used to map the brain's electrical activity. They work by stimulating various areas of the brain and measuring the brain's electrical response.

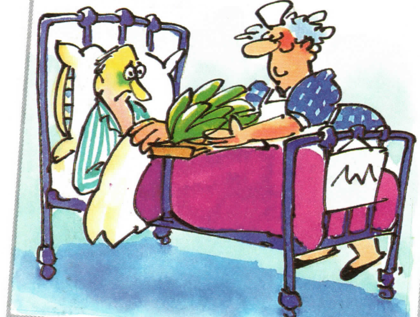
__Five SQUIDS__ are incorporated within a single cylinder in this model, which surrounds patients with hi-tech machinery.

The patient lies in a darkened chamber with a SQUID helmet on. He sees bright flashes of light when that part of the brain dealing with vision is stimulated, or hears a high-pitched tone when the brain's auditory receptors are stimulated. This can be very useful in neurology, the study of the body's nervous system. If the optic nerve is stimulated, but the patient does not see a flash of light, then the brain's visual centre may be damaged.

Just amazing!

BANANA SPLIT

UNRIPE, GREEN BANANAS HAVE BEEN FOUND TO CONTAIN A SUBSTANCE THAT CAN BE USED TO CURE STOMACH ULCERS.



Paul Raymonde

NUCLEAR COLLISION

SUPER COOLING

BRAIN POWER

SUPER COMPUTERS

FORECASTING THE WEATHER is a very complex task. So is mapping the air flow around the body of a new car or modelling the sudden explosion of a giant star.

To do any of these tasks, you need one of the new generation of supercomputers which can perform up to 16 billion calculations a second.

Weather models

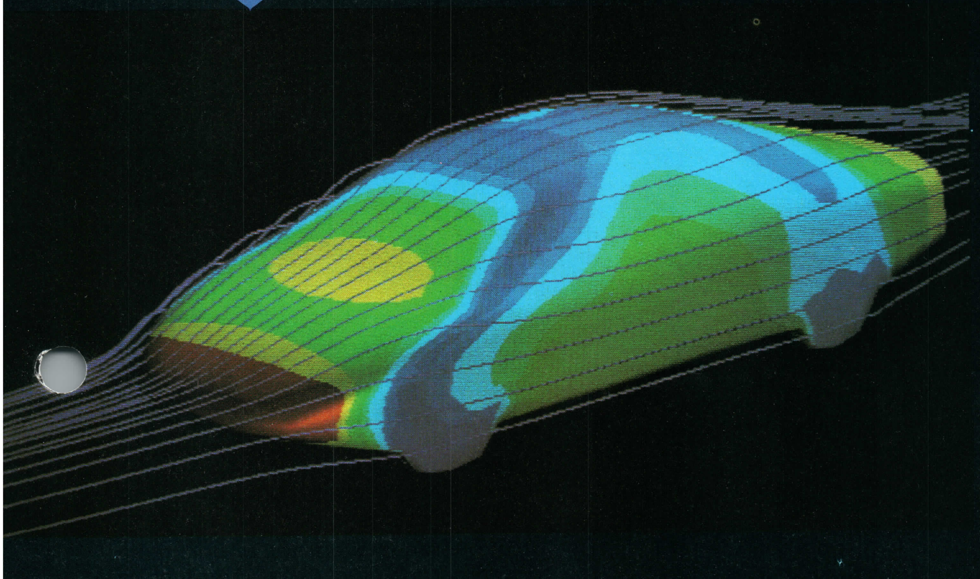
At the European Centre for Medium-Range Weather Forecasts in Reading, Berkshire, UK, a £20 million Cray Y-MP C90/16 supercomputer is fed daily with vast amounts of information gathered by orbiting satellites, balloon-borne instruments and ground equipment. The Cray feeds all this data into a detailed mathematical 'model' of how weather systems operate and comes up with a global forecast for up to ten days ahead. If you tried to make such forecasts with an ordinary computer it would be hopelessly out of date before it could ever be announced!

Air resistance

Other supercomputers have been put to work by automobile and aircraft manufacturers. In the past, the only way to determine the air resistance, or drag, of a new car was to run a number of tests on various different models and prototypes in a wind tunnel. This was both expensive and time-consuming. But now, companies such as General Motors in the United States, Mazda in Japan, and Jaguar in Britain have enlisted the aid of supercomputers in their car designs.

David Parker/SPL

The Cray YMP Space C90/16 Super Computer has 16 powerful central processing units, each of which can perform 1000 million calculations per second.



Hank Morgan/SPL

Even before a prototype has been built, the Cray supercomputer models the flow of air around the body of a new car at General Motors.

Super sifter

The supercomputer simulates what happens in a real wind tunnel by sifting through countless equations and a mountain of data.

The same computer can also reveal ways to make an engine run more efficiently so that it burns less fuel or gives off less pollution. It can even show what would happen if a

car crashed into a wall at, say, 40 or 60 kilometres an hour.

By analysing the results, engineers may then be able to improve the safety of the design while still retaining a lightweight structure.

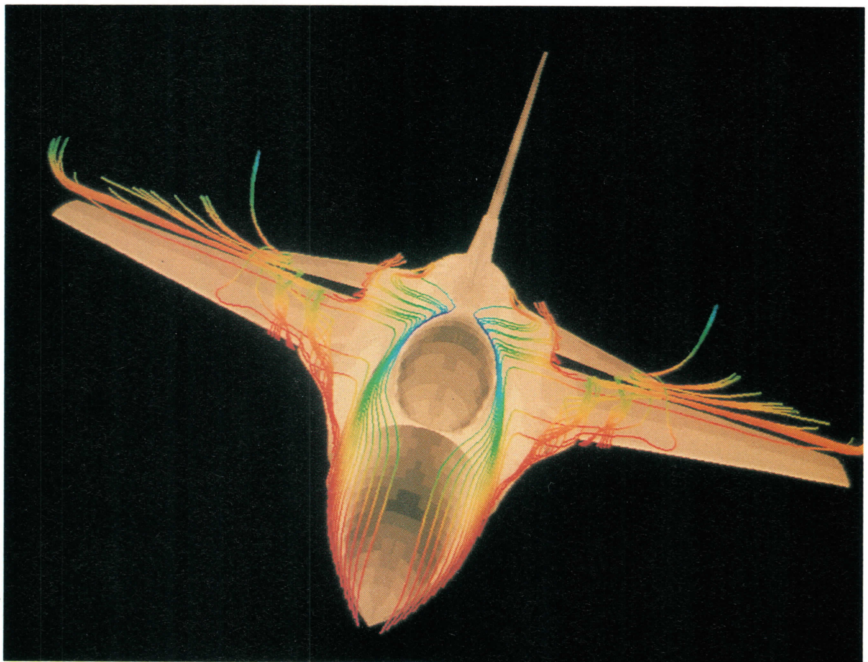
Atom smashers

At the Lawrence Livermore National Laboratory in California, USA, a supercomputer allows scientists to smash together imaginary nuclei. During such an experiment, researchers tell the computer to take several 'snapshots' of what is going on. Each snapshot shows a stage in the impact between two nuclei travelling at speeds approaching that of light.

Represented as brightly coloured droplets on a screen, the nuclei come together, wobble and stretch, and then either break apart again or stick together. By studying these pictures, the Livermore researchers hope to understand better the results of their actual experiments with nuclear collisions.

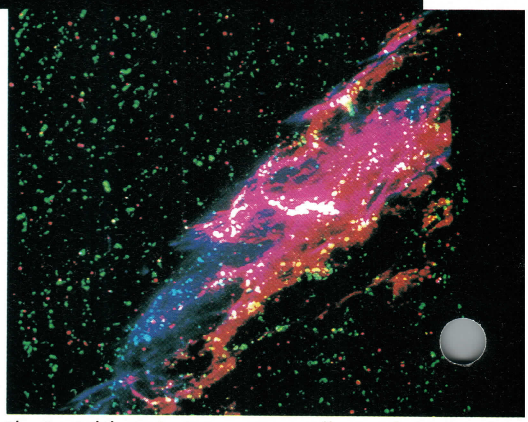
The Universe's secrets

At other labs, too, much basic research is being carried out with the aid of these giant computer systems. In discovering how galaxies form, how the chemical processes within our own bodies take place, and even how the next generation of high-speed computers may be built, today's supercomputers have a vital part to play.



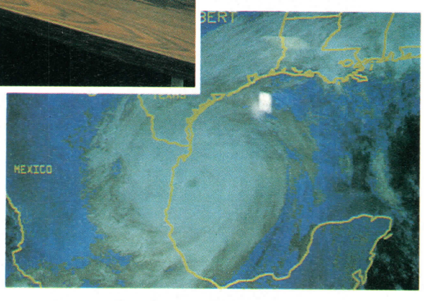
Dale Boyer/NASA/SPL

***The airflow** around the proposed design for the F–16 jet fighter was simulated without the expense of having to build several models and test them in a wind tunnel.*



Dr John R Dickel/SPL

***Supercomputers** are also used to test theories of how galaxies form. The supercomputer's predictions can then be compared with what we see in the sky.*



Gamma/Frank Spooner Pictures

Gamma/Frank Spooner Pictures

***Hurricanes** are tracked and their likely course predicted (inset below) by supercomputers at weather research centres. This way people in the path of a hurricane can be warned.*

Costly though they may seem, supercomputers quickly prove their worth. Within months of its installation, a supercomputer at the American ARCO Oil and Gas Company helped find ways to pump out five per cent more oil from the huge Prudhoe Bay field off Alaska's coast. The total value of this oilfield has been estimated at over $100 billion. Five per cent of this colossal sum is $5 billion – money that ARCO might otherwise not have earned.

Already, in the race to build the world's fastest machine, supercomputer designers have come up with some amazing schemes. Among the strangest is the cooling system devised to carry away waste heat from the CRAY–2 computer. The electronic components of the CRAY–2 are so densely packed, and give off so much heat, that without proper cooling the entire computer would melt down within minutes!

To avoid this, 900 litres of a special liquid, known as fluorinert, are pumped continuously over and around the CRAY's circuit boards.

In the future, even more exotic ideas in supercomputer design seem certain to emerge.

Just amazing!

POCKET-SIZED

AS THE MINIATURIZATION OF CHIPS CONTINUES, COMPUTERS WILL GET SMALLER AND SMALLER. YOU SHOULD BE ABLE TO PUT A SUPERCOMPUTER WITH THE POWER OF A 'CRAY' INTO YOUR POCKET.

Paul Raymonde

THE FIFTH GENERATION

- SUPERCONDUCTORS
- OPTICAL FIBRES
- NEURAL COMPUTERS

COMPUTERS OF THE future, the fifth generation, will be totally unlike any in use today. Some will be built from superconductors through which electricity can pass without resistance at ultra-high-speed. Others will calculate using beams of pure light. And still others will be wired up in the same way as a human brain.

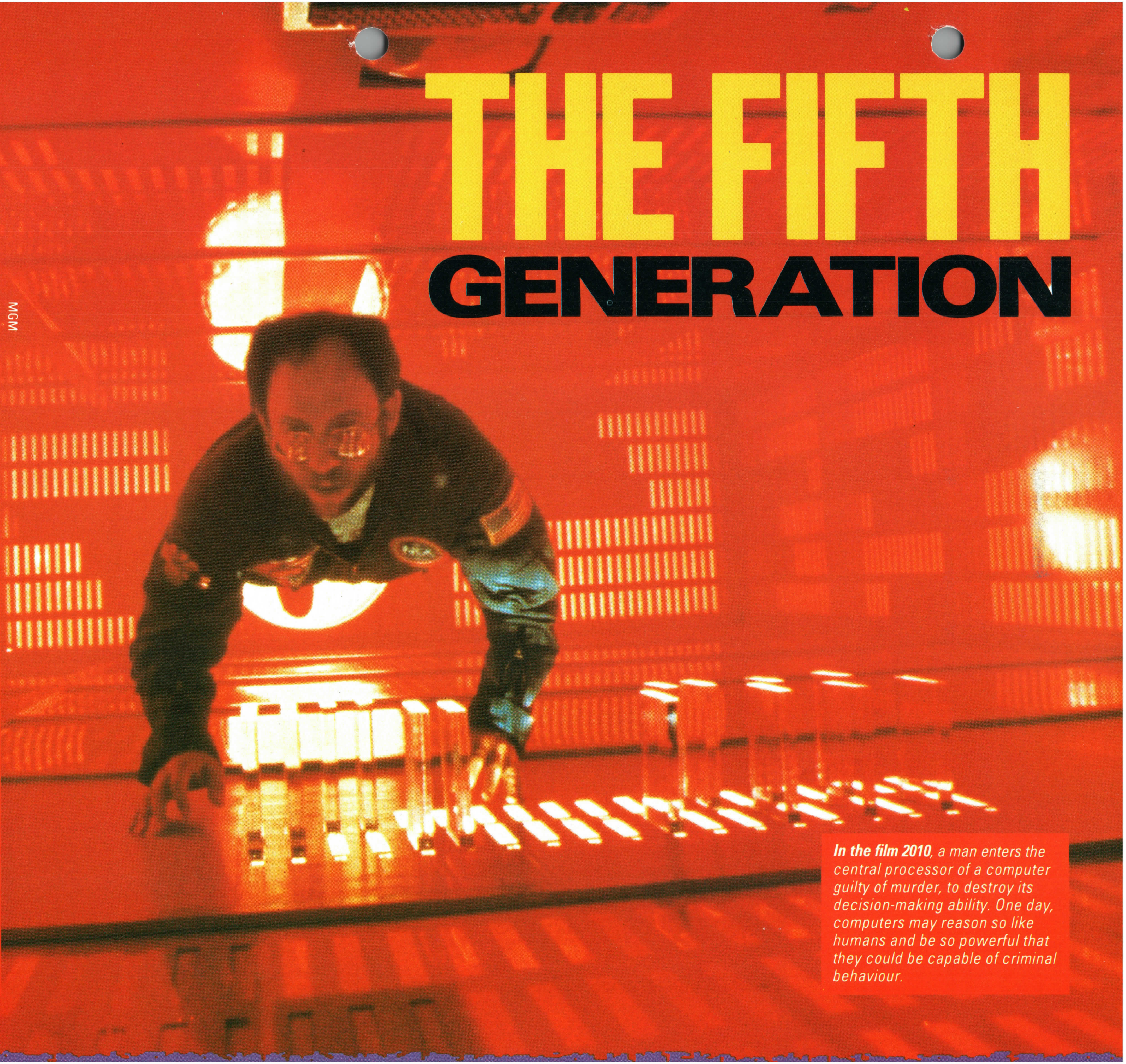
Today, almost all computers are constructed from silicon chips. Each chip contains thousands of transistors that act as tiny switches in the computer's processing section and memory. One way to make a computer faster is to cram more transistors on to a single chip. But as that becomes increasingly difficult, scientists are turning to other methods of boosting the computer's power.

Electricity travels relatively slowly through silicon. However, chips made from a substance called gallium arsenide allow current to pass through five times as fast. Already, a few supercomputers are being built from this new material.

Supercool

When some substances are cooled down close to absolute zero (the coldest temperature possible), they become superconductors. In this state, they let an electric current pass through them with virtually no energy loss.

Switches based on these super-cooled superconductors, known as Josephson junctions, have been

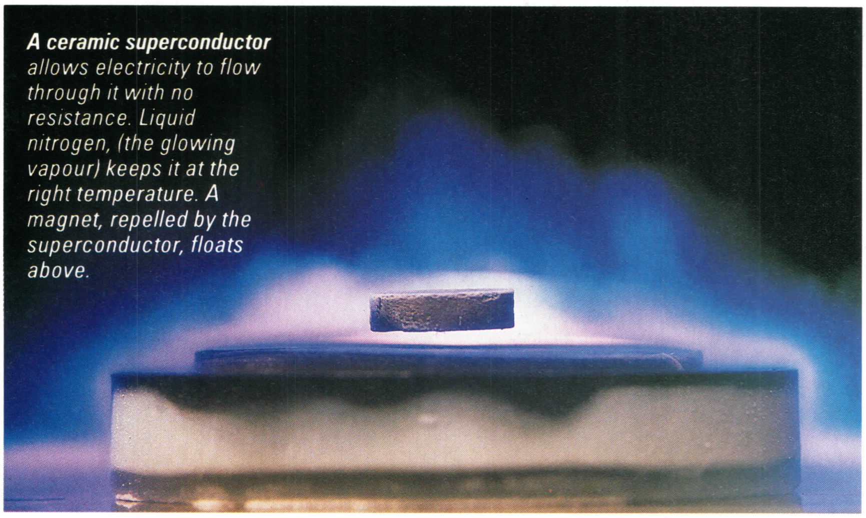


MGM

***In the film 2010**, a man enters the central processor of a computer guilty of murder, to destroy its decision-making ability. One day, computers may reason so like humans and be so powerful that they could be capable of criminal behaviour.*

tested in the laboratory. Incredibly, they can flip on and off trillions of times a second – much faster than any conventional switch. Yet there are big problems still to be overcome in working with a computer that runs at such a low temperature.

Those problems may disappear if one day there is discovered a new class of substances that behave as superconductors at room temperature. A computer based on these would need no special cooling and yet could run at high speed using virtually no power. However, the highest superconducting temperature so far achieved is -146.3°C. This was attained under strictly controlled laboratory conditions for a short period of time. So far no method has been found by which superconductors may be produced in a commercially viable form.



***A ceramic superconductor** allows electricity to flow through it with no resistance. Liquid nitrogen, (the glowing vapour) keeps it at the right temperature. A magnet, repelled by the superconductor, floats above.*

David Parker/IMI/SPL

Today, tiny bright flashes of laser light can be sent hundreds of kilometres along fine strands of specially made glass, called optical fibres. In the future, these fibres will be used to replace ordinary wires in a revolutionary new type of computer – the optical computer. In place of transistors, such a computer will have transphasors – switches that work using pulses of light instead of electricity.

The power of light

Experimental transphasors have already been made to flip on and off a thousand times faster than any present-day switch. And, unlike a transistor, transphasors can be built to handle the switching of several incoming signals at once. Beams of light can criss-cross and overlap without any risk of them becoming mixed up, whereas crossed electric currents would get hopelessly confused.

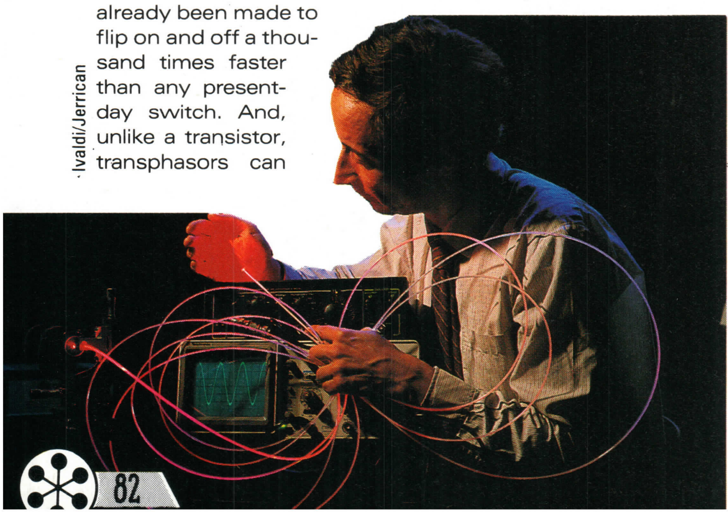
Optical computers would have other advantages, too. Many instructions or pieces of data could be sent through such a computer along the same optical fibre.

A computer working with light could be linked directly to a future phone network of optical fibres. There would be no need for any special equipment to change electrical signals to light signals and back again.

The most sophisticated computer ever made is inside your head. You may not be able to add or multiply as fast as a man-made computer, but you can imagine, create, understand and think in other ways far better than the most powerful supercomputer on Earth. If human brains are so good at abstract thought, why not build computers in the future that mimic the way our own brains work?

The human brain

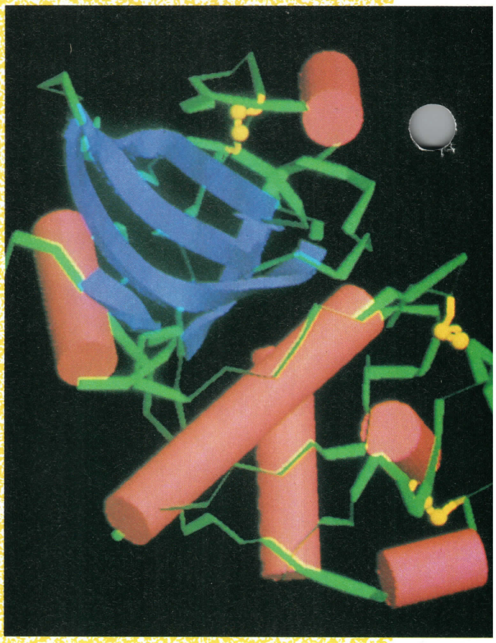
Right now, teams of scientists around the world are pursuing that very goal. Their hope is to design so-called neural computers, whose switches are linked together in much the same way as human brain cells are. The task is enormous. An adult brain contains up to 100 billion cells, or neurons, each of which connects to about 10,000 of its neighbours. What is more, unlike an ordinary computer that does one calculation after another, all of our brain cells work together in parallel. Parallel working – doing several jobs at the same time – is the most important way to improve computers.



Ivaldi/Jerrican

***Optical fibres** are fine strands of glass through which tiny, bright flashes of light send information. They will replace electric cables in computers of the future. The fibres can be twisted, coiled and bent.*

BIOCHIPS



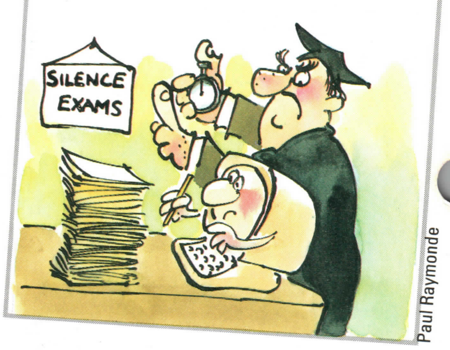
Dr Arthuur Lesk/SPL

The basis for a computer built on the lines of the human brain could be the biochip. Constructed on the basis of protein molecules (such as the one shown in the computer graphic image above) and specially designed for the task, biochips could be made to work like a complicated switch. Since they would be built of living material, networks of biochips might be able to organize themselves in different ways or even repair themselves if damaged.

Just amazing!

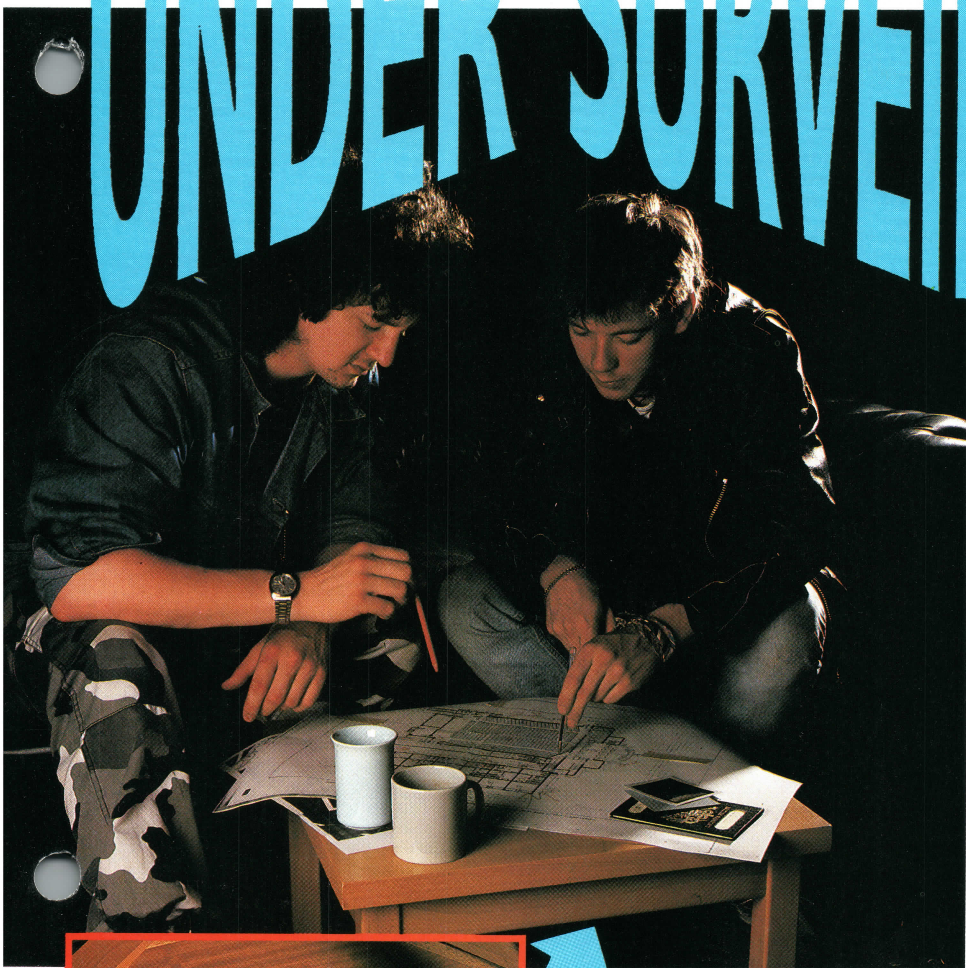
FAST WORKER

THE NEW INTEL 860 'SUPERCHIP' CAN DO AN ASTOUNDING 150 MILLION OPERATIONS IN JUST 1 SECOND – OR 9000 MILLION PER MINUTE.



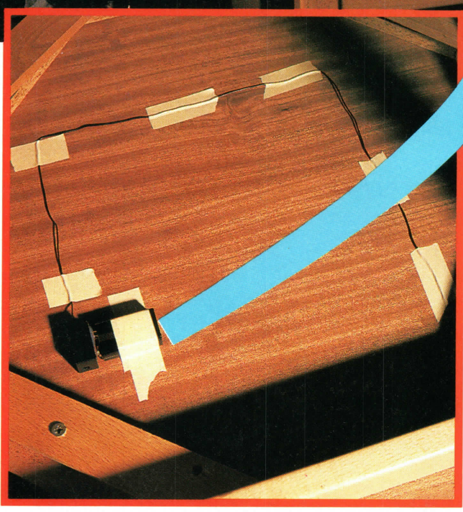
Paul Raymonde

UNDER SURVEILLANCE



- ELECTRONIC TAGGING
- TELEPHONE TAPPING
- VOICE PRINTS

Ray Duns



***No conversation is safe** from the eavesdropper. Under the table (inset) there is a bug – a tiny microphone and radio transmitter.*

ALL GOVERNMENTS LIKE TO keep an eye on their citizens. They like to watch criminals, spies and some even keep people who simply disagree with government policy under surveillance. Modern electronics can greatly help security men to keep watch on any individuals they consider a threat.

No-one much objects to the government keeping an eye on criminals – especially those that have already been convicted and sentenced. Usually criminals are put in prisons where their movements are restricted so that they can be watched 24 hours a day.

The problem is that prisons are overcrowded. New ones are very expensive to build. Also, prisons can be 'breeding grounds' for crime, allowing young criminals to learn from older ones. Prisons take people away from their families, causing social problems. Prisoners rarely have the opportunity to work and earn their keep – so they get out of the habit of working, making them more likely to turn to crime again when they get out.

No escape

One way around these problems is not to send people to prison, but to keep a check on them round the clock in the community. In some countries electronic tagging is now being used to do just that. A small radio transmitter, attached to the person, sends out a specially coded transmission that can be constantly monitored. Essentially it is the same system naturalists have been using for years to track animals and study their behaviour.

Currently, electronic tagging is being used in the United States on prisoners on remand – that is, people who have been arrested and charged with a crime, but not yet tried or convicted. Their movements are monitored so that they cannot leave their home State undetected. If they try to remove the tag, the police are alerted immediately and they will be taken back into custody.

Catching criminals

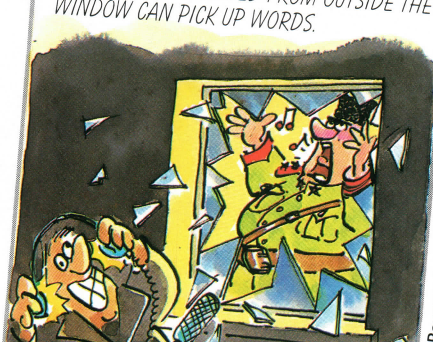
There are plans to extend this scheme to convicted criminals. Their movements can be restricted to their own home and their workplace. If they went anywhere else the tagging system would immediately alert the police. A curfew could be applied so that the convicted criminal would have to be at home at certain times.

Electronic surveillance is also

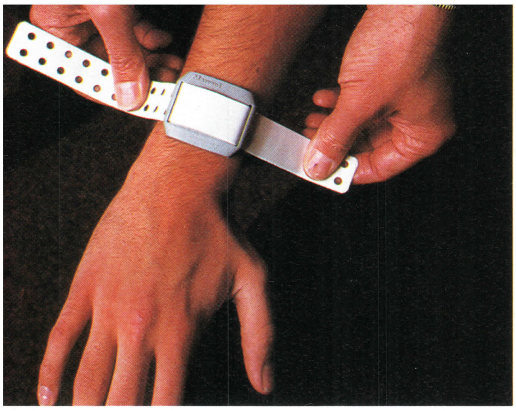
Just amazing!

LIGHT BUGS

IT IS NOW NOT NECESSARY TO PLACE A BUG IN A ROOM. WHEN SOUND HITS A WINDOW PANE, THE GLASS VIBRATES SLIGHTLY AND LASER LIGHT REFLECTED FROM OUTSIDE THE WINDOW CAN PICK UP WORDS.



Paul Raymonde



__Electronic tags__ fit around the wrist or ankle. They cannot be removed without the police being alerted.

Derimais/Jerrican/SPL

used to catch criminals. Like everyone else in the modern world, criminals are heavily reliant on telecommunications. So police forces and governments around the world eavesdrop on telephone conversations and other forms of electronic data transmission.

The most frequently applied technique is the telephone 'tap'. When a telephone is tapped, it means that all calls on that number are intercepted and conversations are recorded without the knowledge of the people talking.

Target lines

The tap is made by adding an 'extension' to a particular line at the telephone exchange – and this is activated whenever the target line is used. Targets for telephone tapping include people planning serious crimes, drug pushers, spies and organizations which the government considers 'subversive'.

Electronic surveillance does not stop at individuals. Throughout recorded history, governments have spied on one another. Today, most spying is done by monitoring the communications systems of foreign countries. Not only does this give an insight into matters of policy but, perhaps more importantly, information on trading activities. As trade is the life-blood of the Western world, such 'economic intelligence' is of vital importance.

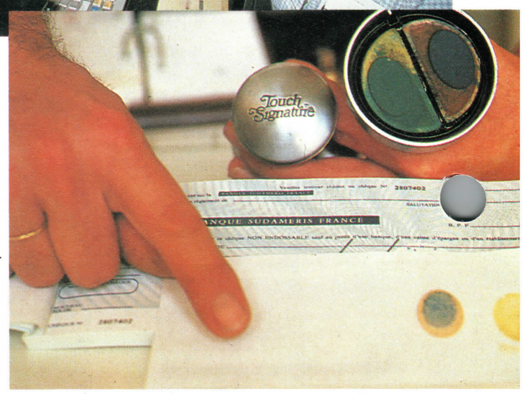
Commercial communications passing through the world's satellite telephone system, diplomatic traffic between embassies and their home countries as well as internal communications within 'countries of interest' are all monitored.

It is possible to do this because most communications systems rely at some stage on a radio link. The physical nature of radio waves means an eavesdropper cannot be prevented from picking them up.

Secret establishments need to prevent access to unauthorized people. Two ways of doing this are the use of voice and fingerprint recognition systems. Like fingerprints, a person's voice is completely unique and can be used to identify authorized individuals.

Of the two, voice recognition is the more difficult to achieve. To work, such a system needs to be programmed to recognize a particular voice. The computer can compare this 'voice print' to the voice of someone wanting to enter the secret establishment.

Gamma/Frank Spooner Pictures



Gamma/Frank Spooner Pictures

__Fingerprinting__ is used in some countries to stop bad cheques. The shop stamps two spots on the back of the cheque. The customer presses her finger on the yellow, then the red spot, leaving a 'signature' print – but not staining her finger.

INTO THE FUTURE

TOMORROW'S JOURNEY

▲ *Open borders will one day make entering another country much quicker – traditional passport control will be a thing of the past.*

▲ *Instead of a passport, travellers will have a 'smart card' confirming identity and providing a central computer with health and other important information.*

▲ *The central control system will immediately register any undesirable aliens – criminals or terrorists – and secretly tip off security men.*

Joe Lawrence

DOWN TOWN

EARTHSCRAPERS

NUCLEAR PROTECTION

SINKING CITIES

AS POPULATION GROWTH forces cities to find ever greater amounts of accommodation for their citizens, planners must look either outwards, upwards or downwards.

Spreading outwards, beyond the city limits, destroys one of the few remaining 'free resources' that the planet possesses – the countryside. Spreading upwards not only destroys the skyline, leaving unnatural and, some would say, oppressive views to city inhabitants, but social research has shown that high-rise living is unduly stressful, tending to isolate people from their neighbours and encouraging vandalism and violent crime. Many planners are, therefore, beginning to look beneath their feet.

One way of building underground is known as 'earth-sheltered' construction. A house is built in an excavation, then covered with a layer of soil. Not only do such buildings blend inconspicuously into the surrounding countryside but fuel bills can be greatly reduced due to the insulating properties of the earth. At present, this is the main type of underground housing, with more than 10,000 houses in the USA and over 4 million in China.

Newfoundland and Labrador Hydro

***Constructing** the surge chamber of the Churchill Falls hydro electric plant.*

Newfoundland and Labrador Hydro

***The powerhouse** floor of the Churchill Falls plant, Canada, 253 metres underground.*

One of the best examples of earth-sheltered technology is the Terraset Elementary school in Virginia, USA. Built in the mid-1970s, the school buildings, which cover an area of 7,000 square metres, were overlaid with a 60–90 cm layer of earth. The entrances were 'countersunk' and the covering earth was made into outdoor play and recreation areas.

Clean air

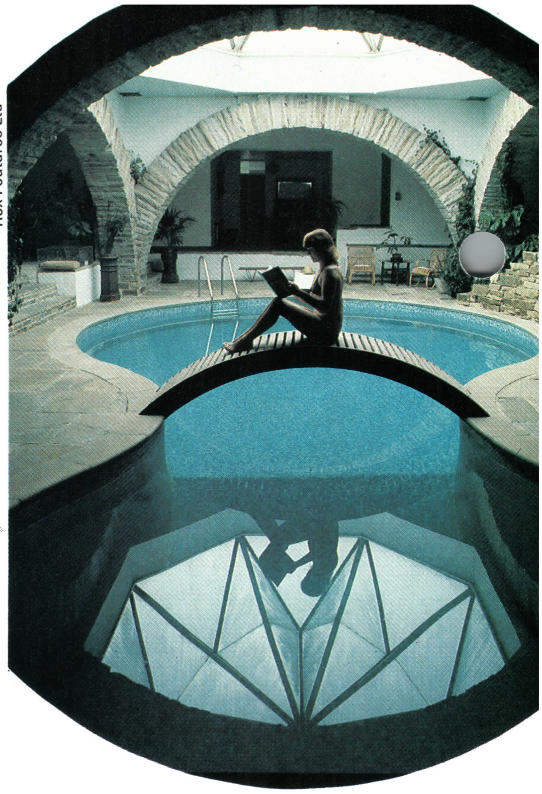
Another type of construction is the semi-subterranean building. This has proved popular for many large municipal buildings, such as multistorey car parks. The Law Library of the University of Michigan has all its three storeys underground; the Smithsonian Institution Museum Complex in Washington DC is 96

per cent underground; and the Civil and Marine Engineering building at the University of Minnesota is 95 per cent below the surface.

Subterranean buildings are ideal for science research and industrial complexes which need clean work environments, as few airborne pollutants find their way in.

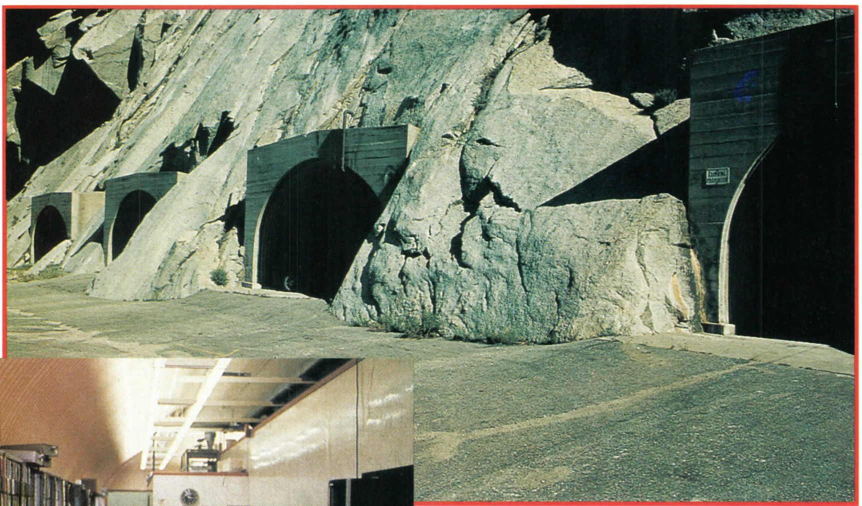
Lastly, there is totally subterranean construction. Construction costs can be half that of conventional housing, particularly if an old mine, underground railway line or natural cavern can be altered to form a factory or trade complex. Similarly, as the temperature of most rock areas in warm countries remains fairly constant (at 7 to 10°C) to a depth of several thousand metres, heating costs can also be reduced.

Nuclear bomb shelters are, of course, built underground because a large thickness of earth and concrete is the best protection from nuclear blast and radioactive fallout. In Sweden, for example, where 80 per cent of the population can be sheltered, many public facilities, such as swimming pools and health centres, have been built underground so that they could be used in the event of a nuclear war.

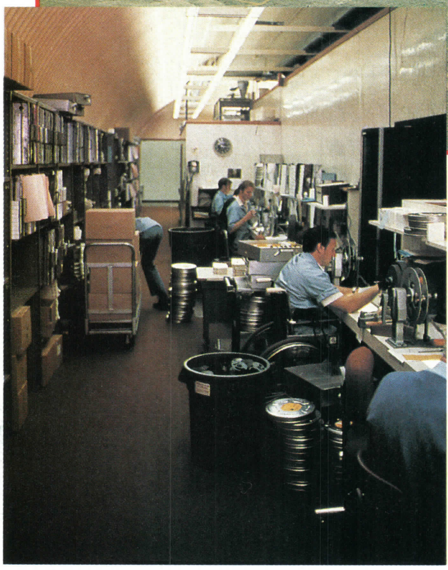


Rex Features Ltd

***Underhill** is a semi-subterranean, 4-bedroom house in the Peak District near Huddersfield, UK.*



Church of Jesus Christ of Latter-day Saints



Church of Jesus Christ of Latter-day Saints

***The Granite Vaults** – ground level tunnels bored beneath the Wasatch Mountains in Utah, USA – are the storage facility for the Mormon Church's microfilm data of world members (left).*

Similarly, key military facilities are normally built deep underground. The North American Air Defence Command (NORAD), for example, is virtually impregnable, having been constructed in caverns and tunnels deep inside Cheyenne Mountain at Colorado Springs.

Looking forward, the next step, some architects are predicting, will be 'earthscrapers' – inverted tower blocks that go underground instead of skywards.

Geofrontier

With this in mind the Japanese Government launched the 'Geofrontier Project', at a cost of around £70 million, to develop techniques to build underground power stations, offices and even homes, more than 50 metres beneath the surface.

The project initially involved the creation of a large dome-shaped cavity, 50 metres wide and 30 metres high, with the floor 80 metres below the surface. The new cavern was designed to house a substation, but the importance of the development was to find out what it is like to try and build such an underground complex.

Earthquake-proof

One advantage of moving underground, particularly in areas like Japan, is that it reduces the risk of earthquake damage. Lined with flexible concrete and steel walls, the excavation 'rides' any shock waves caused by Earth tremors – the shaking recorded below the surface is less than one-third of that on the planet surface.

The current stumbling block is legal rather than technical. At present Japanese law states that land owners at the surface own the rights from the centre of the Earth to out into the Universe.

IN ANOTHER WORLD

In 1989 Signorina Folini, a 27-year-old Italian researcher, spent four months in a specially built house some 10 metres below the earth's surface in New Mexico's Lost Cave. The purpose was to observe the psychological effects of isolation underground. She had no clocks, radios or external light source to give her a sense of time. The experiment showed that she fell into a routine of staying awake for 23 hours and then going to sleep for 10. The isolation also took its toll on her memory, concentration and reasoning ability. Stefania was underground for four months, but she thought she had been in isolation a month longer.

Just amazing!

BORING WORK

THE DEEPEST HOLE EVER DRILLED IS IN THE USSR. IT HAS REACHED 13 KM BELOW THE EARTH'S SURFACE – THE TARGET IS 15 KM. TEMPERATURE AND PRESSURE INCREASE SO RAPIDLY UNDERGROUND THAT PROGRESS HAS SLOWED TO 500 METRES A YEAR.

Paul Raymonde

Computers will dominate the home of the future. From your central console, you will be able to control heat, lighting, and the home's electrical equipment.

Esto Photographics

DESIGNS FOR LIVING

- PRE-CAST HOUSES
- ENERGY SAVING
- COMPUTERIZATION

Annet Held/Arcaid

Modern architects have come up with some weird and wonderful homes. This design by Piet Bloom in Rotterdam harbour places houses above shops.

THE SHAPE OF TOMORROW'S homes will not be very different from today's. Apart from a few weird and wonderful designs from revolutionary architects, homes will take the same basic shape as they have done for many years.

However, the way houses are built may be revolutionized by different construction materials, especially plastics. Plastics come in many forms, and can be made cheaply and easily for almost any purpose. They can be made light yet strong enough to take heavy loads, and transparent to admit heat and light but still insulate against the extremes of cold and heat.

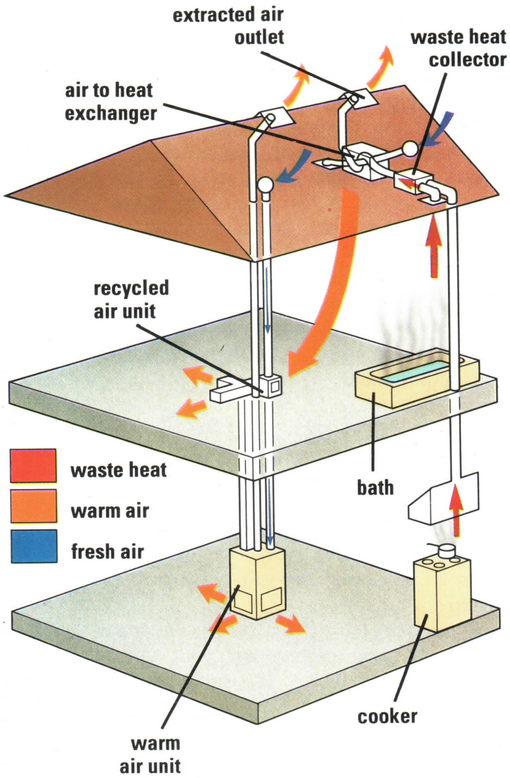
The most widespread use of plastics will be factory-built wall panels and modules, which can be engineered by robots to accuracies of one-quarter of a millimetre. Already in Japan, 20 per cent of homes are assembled on site from ready-made steel and lightweight concrete panels.

Design-it-yourself

Home-owners can draw up their own design on a special computer program, which contains thousands of permutations. Within two weeks, panels or modules of lightweight steel and concrete are delivered to the site. They may even come complete with doors, windows and wiring, and can be assembled in a day, leaving just a week or two to finish the plumbing, electrics and painting.

Space technology

Plastics are not the only materials that could revolutionize building methods. In places that are ex-



Mark Franklin

***Central heating systems** are now being designed to re-distribute the warm air from cooking and bath water. An air-to-heat exchanger sends warm air back into a unit which mixes fresh, warm and recycled air.*

Already there is an electronic unit that gives you complete control over your bath or shower. By programming its microprocessor, you can determine the exact temperature and rate of flow of the water. It will even switch itself off when the bath is full and give an audible warning when it is ready.

The need for hygiene has changed the design of hand driers, taps and soap dispensers. Soon they will all be 'triggered' by breaking an infra-red beam as you put your hands underneath them.

Videophones

The television set and music centre, linked to the telephone and central computer, will become more than a means of entertainment. Already researchers in Japan have linked a video camera into such a system, so that viewers can transmit pictures and sound from their living rooms directly into a TV studio or to the homes of anyone they choose – giving them two-way communication by videophone.

A leading European electronics company has developed a hi-fi and TV system that can be networked around the whole house, and can be controlled from any room by either remote control units or touch sensors built into the walls. It allows you to choose a record, CD or TV programme and control it from any room in the house. You can even programme the unit to play music or switch on the TV days or even weeks ahead.

Multi-networking

Transmitting video and computer signals within the telephone network is now possible. In many countries, telephone exchanges have been modernized so that they can handle vast numbers of signals at a fast enough rate to cope with computer data transmissions.

An important step was to replace the old copper cables with fibre-optic cables so that the information could be sent digitally – as pulses. This has opened up the possibility of linking every home to just about any service. As a result, there would in theory be fewer reasons to go out – for example, all your shopping could be done from home.

NEW SHAPE SHOPS

Geodesic domes are lightweight, strong, and spacious structures suitable for very large or very small dwellings. Developed by US architect, Buckminster Fuller in the 1950s, these spherical structures are assembled from simple shapes, such as triangular frames or flat planes.

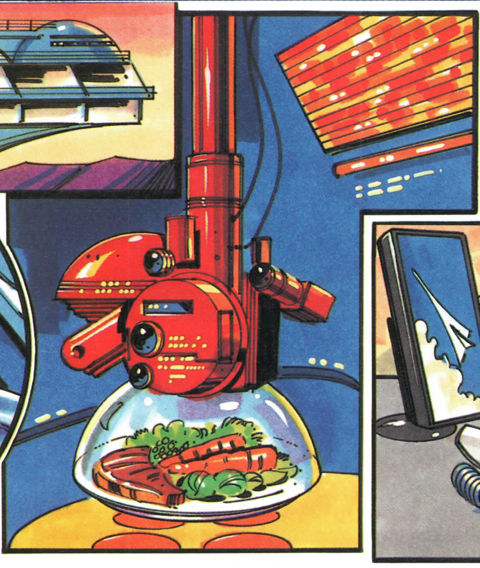
Geodesic domes have been built as exhibition pavilions and shopping centres. They are simple and inexpensive to construct, and provide well-lit, spacious accommodation, without the need for internal supports.

The Walt Disney Company

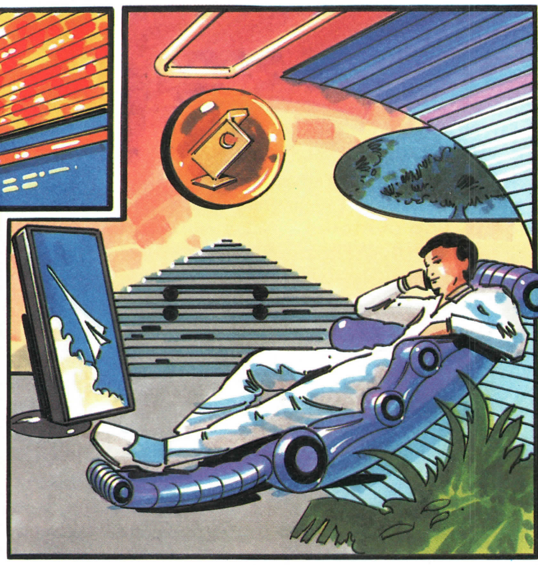
INTO THE FUTURE

REMOTE CONTROL

▲ *The householder of the future will be able to telephone the central computer that runs the home and issue orders for the computer to carry out.*



▲ *He will be able to tell the computer to record his favourite TV programme, switch on the oven to cook a meal, start the washing machine and turn on the heating.*



▲ *When the householder returns, the computer will have taken care of everything. The house will be warm, a meal will be ready and the washing done.*

Joe Lawrence

MICRO SOUND AND VISION

Redferns

Future micro *technology will enable you to watch a video image of a pop group, such as Big Fun (inset), as you walk down the street listening to their latest hit.*

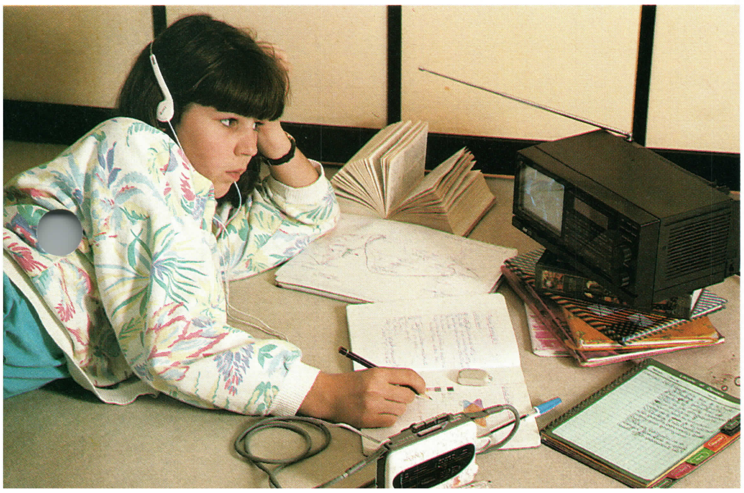
Michel Tcherevkoff/Image Bank

IN THE INCREDIBLE shrinking world of micro-electronics, computers, televisions, video players and digital stereos are fast approaching the point where the machines are smaller than the batteries that power them.

Gaillard/Jerrican

Among the first electronic devices to be made small enough to clip on to the belt of a jogger or commuter were cassette-tape players. The latest compact disc (CD) technology is now also available in 'Walkman' form.

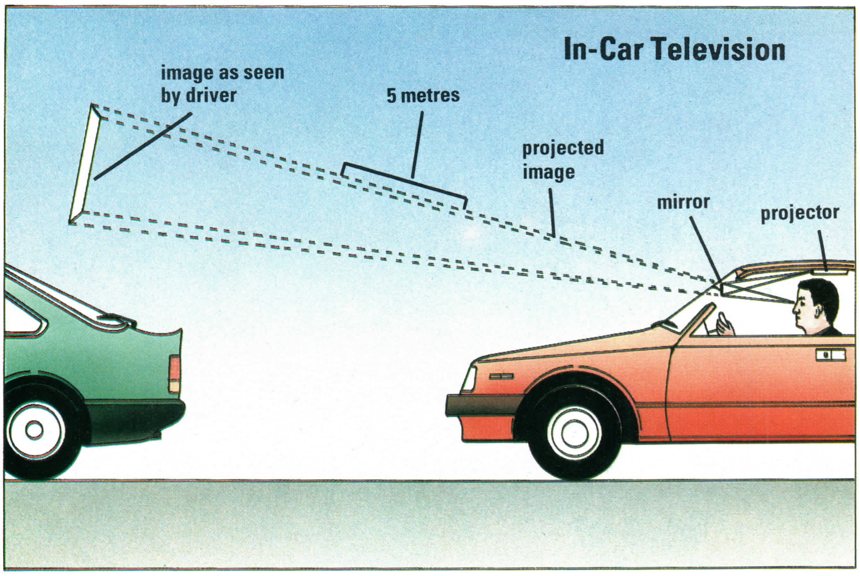
CD players, which work by scanning microscopic pits and blanks on a compact disc's mirror-like surface with a light beam, have fairly small moving parts to begin with. In addition, there is no need for contact between the pick-up device and the sound surface, as, for instance, there is in the case of a record player. Thus CDs can be moved about without harming the sound or the machine.



The personal cassette player *is one of the great manufacturing success stories of the 20th century. Its inventor, Sony, sells over 10 million Walkmans worldwide every year, with rival companies making over 25 million imitations.*

Pocket televisions

Miniaturising television sets is more difficult. The problem is how to produce clear, moving pictures on a very small screen. Most ordinary TVs use cathode-ray tubes (CRTs), in which electric and magnetic fields control a beam of electrons fired at a luminescent screen. Pocket televisions, however, are now available that use an advanced kind of LCD (liquid crystal display). In contrast to CRTs, LCD screens run off only about 10 volts instead of 10,000 volts, and around one watt of power instead of tens of watts. Above all, they are extremely compact.



Matthew White

***Autovision** is a television viewing system for cars, which gives the driver the illusion that the image is in his or her normal field of vision.*

Liquid crystal display

An LCD consists of a layer, about 10 micrometres thick, of liquid crystal. This is a substance in which the molecules can be made to line up in different ways by an electric field. The liquid crystal is sandwiched between two small glass plates. On to the inner surface of these plates, transparent electrodes are arranged in a grill pattern. These electrodes control how the molecules of liquid crystal are lined up.

Natural light falling on to the back of the LCD sandwich first passes through a polarizer, which makes the light vibrate in just one direction. The amount of polarized light reaching the front of the screen is then determined by the orientation of the liquid crystal molecules at each point.

One drawback of simple LCDs is that they cannot keep up with the rate at which a television picture changes. For this reason, manufacturers are now also placing small transistors at each grid point on the screen. The transistors act as fast, sensitive switches to control each element of what is called an active matrix display. Tiny red, green and blue filters can be fabricated at each grid location on the upper glass plate to give a colour picture.

THE LAST FRONTIER

Portable electronic equipment is just about as small as it can possibly be. The designers of portable video cameras and recorders, personal computers and pocket telephones all face the same problem. If the equipment is made too tiny it becomes impractical for humans to operate.
Another limiting factor is the size and weight of the batteries needed to power pocket-sized devices. Developments in miniaturisation of electronic circuits have far outstripped progress in battery technology. As an example, the smallest portable telephone available has a body, including keypad, display panel and aerial, that weighs less than 200 grams. The rechargeable battery used to power this device weighs at least half as much again.

The portable TV is, however, facing a further revolution in its miniaturization. Imagine a device as small as a packet of chewing gum that fits in front of one eye and produces a full-size video image. Private Eye, developed by an American company, does just that. The device weighs just 60 grams and measures about 8 x 3 cm, with a viewing window 2.5 cm across. A user who holds the window up to one eye sees an image equivalent to a 30 cm TV screen half a metre away. This is superimposed on whatever the other eye happens to be looking at and can be seen through if the user focuses on a point beyond the 'screen'.

Under wraps

The technology behind Private Eye is still secret, but there are two ways such a device could work. First, a small vibrating mirror might be used to direct a narrow beam of light on to a screen. If this is done fast enough, a complete picture on the screen would seem to appear instantaneously. Alternatively, a personal video could be built around an LCD display with a system of lenses to focus the image.

In future, devices such as Private Eye may be linked with pocket computers, video games and high-performance audio devices to provide the ultimate in multi-media entertainment.

Sharp Electronics (UK) Ltd

***Sharp IQ** electronic organizer functions as a diary, address book and database as well as a calculator.*

***The Sony Video Walkman** is a portable colour television and video recorder (using 8 mm film) with a tuner/timer.*

Gamma/Frank Spooner Pictures

Just amazing!

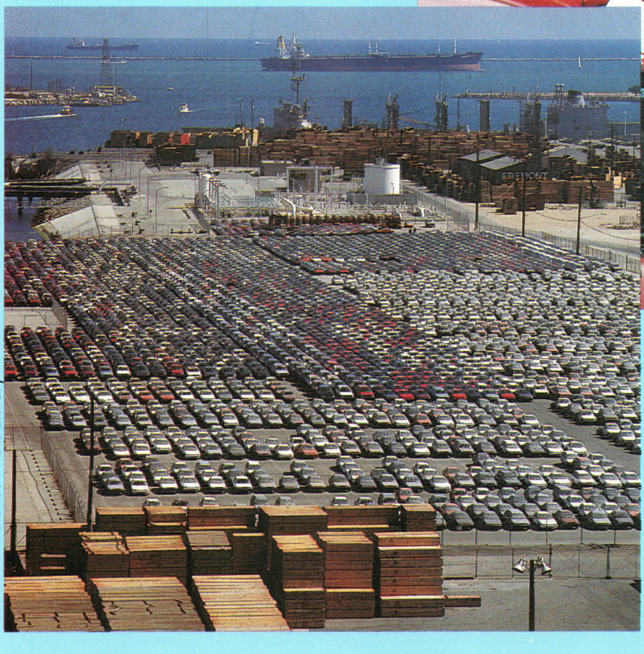
HARD SELL

THE WORLD'S FIRST TALKING ADVERTISEMENT FEATURED IN THE OCTOBER 20TH 1989 SPECIAL EDITION OF BUSINESS WEEK. EVERY TIME IT WAS OPENED, A MICROCHIP UTTERED ITS 42 WORD MESSAGE.

Paul Raymonde

MASS MADE TO ORDER

Tony Stone Photo Library, London



Alex Bartel/Science Photo Library

***Mass-produced** – but with many options for the individual customer, hundreds of different imported models wait at the docks in Long Beach, California, USA (left).*

THE NEXT INDUSTRIAL revolution will be customized manufacturing. Having had his or her fill of the fruits of mass-production, the customer of the future will expect mass-produced goods to be made-to-measure – in batches of one.

Today, manufacturers of mass-produced goods are facing their toughest test since the introduction of the assembly line, first fully exploited by car-maker Henry Ford early in the 20th century. To meet the challenge, they must rethink how they produce goods and embrace the potential of automatic technology.

Conventional wisdom says that the more you produce, the cheaper each item will cost to make. But this does not naturally lead to flexibility; it is often difficult to modify an item to suit the changing demands.

Traditionally, for example, the 800-tonne presses used to stamp out car bodies in most Western car plants take about 4–6 hours to set up. This means that a minimum number of about 10,000 identical panels (about two week's supply) must be made before it is worth-while changing the dies in the presses.

Smaller batches

In Toyota's Japanese car plant, however, the dies are fitted with quick-release fasteners instead of nuts and bolts and can be slid in and out of the presses in minutes. This means that much smaller batches can be made. Making things in smaller batches means that manufacturers can respond much quicker to changing tastes. In addition, individual production lines can make a greater variety of goods.

CRAFTSMANSHIP

Rolls-Royce Motor Cars Ltd

There is no such thing as a mass-produced Rolls Royce. Every vehicle is hand-made by teams of craftsmen, each working on just one facet. The veneers for the dashboard are cut from American burr-walnut. After passing quality checks, the veneer sheets are soaked in water and flattened in a press before being left to dry for four days. Only then can the craftsmen select the eight pieces of matched wood to make up the apparently one-piece fascia. A primer and three coats of polyester resin lacquer are applied to the finished dash, which is then sanded and polished to produce a glass-like finish.

A similar revolution is taking place in the clothing industry. Already in use are automatic tailoring systems that can make patterns, mark and cut fabric and finish a suit – all from data fed in from a computer terminal in the shop.

The perfect fit

Researchers based at Loughborough University, Great Britain, have developed a scanner that even does away with the tape measure. Using banks of high resolution video cameras, the system takes three minutes to measure up to 60,000 data points on a customer's body. This is used to create a 3-D image that records every curve and bulge.

At the same time, engineers at Belfast University, Northern Ireland, are able to combine the 3-D images with clothes designs to automatically create dress-making patterns. And a team at Hull University, Great Britain, has developed programs that instruct industrial robots to convert fabric into completed garments. Soon, high-street shops will be able to offer made-to-measure suits, at the push of a button, in one hour. And at a price to suit the average person's pocket.

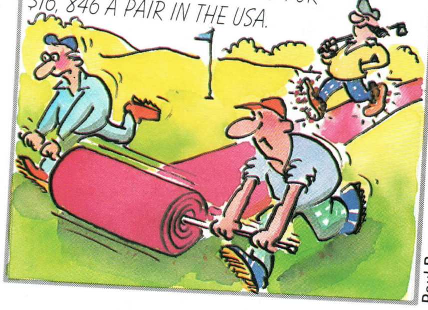
Ross Kinnaird/EMPICS Lectra Systems Ltd

Automatic measuring systems *combined with computerized cutting benches (above), can produce a made-to-measure suit in one hour.*

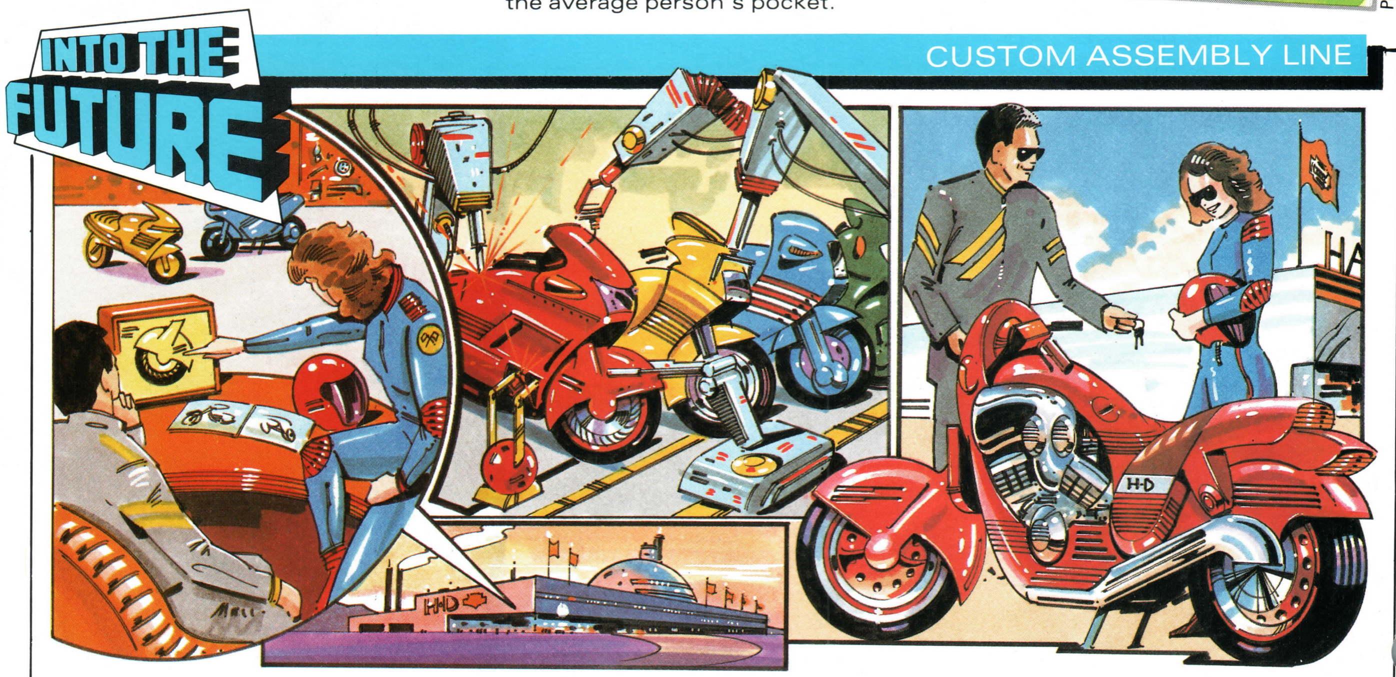
Just amazing!

PAIR FOR THE COURSE

MINK-LINED GOLF SHOES WITH 18 CARAT GOLD TRIM AND RUBY-TIPPED SPIKES ARE THE MOST EXPENSIVE SHOES MADE. PRODUCED BY STYLO MATCHMAKERS INTERNATIONAL OF NORTHAMPTON, UK THEY SOLD FOR $16, 846 A PAIR IN THE USA.



Paul Raymonde



▲ *In the motorcycle shop of the future, customers will be able to choose from a vast number of options, tailoring their machine to their own requirements.*

▲ *The order will be sent to the factory, where robots, instructed by the central computer, will assemble each motorcycle exactly to the customer's specification.*

▲ *Two weeks later the customer will take delivery of a unique motorcycle that has been built with standard parts and carries the manufacturer's warranty.*

Joe Lawrence

AIRPORT 2000

CAUGHT BETWEEN THE NEED to handle greater numbers of air travellers and impose increasingly tough security, airports will need to undergo a revolution in the near future.

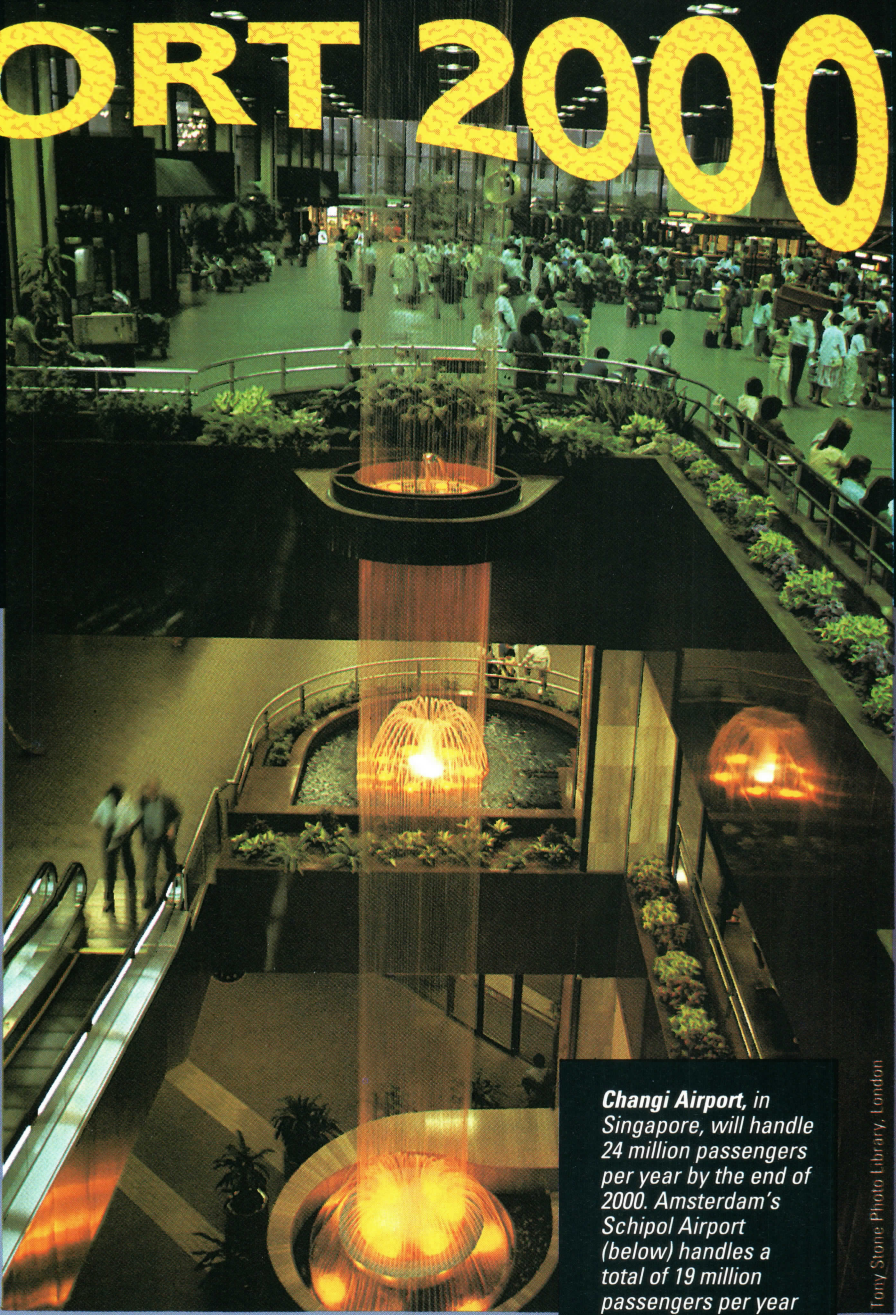
During peak hours at Chicago International Airport, for example, there is a take-off or landing every 39 seconds. Over 64 million people – more than the entire population of the United Kingdom – travel in or out of the airport each year.

One way to relieve the air-traffic jam may be to build many small airports for handling short-haul, Short Take-off and Landing (STOL) planes. STOLports could be built in cities because their runways would take up relatively little space and STOL aircraft make far less noise during take-off than conventional jets. Urban locations would reduce passengers' travel time.

Computerization

Much of the present congestion in airports might disappear if computers and robots took the place of human workers. Automatic ticket machines could take over from staff at the check-in desk; computers could be programmed to answer passengers' questions in different languages, and robot baggage handlers could run security checks.

Already, some international airports are equipped with driverless, computer-controlled monorails that ferry passengers between terminals. In future, people will be quickly



Tony Stone Photo Library, London

__Changi Airport__, in Singapore, will handle 24 million passengers per year by the end of 2000. Amsterdam's Schipol Airport (below) handles a total of 19 million passengers per year with flights to and from 90 countries by over 80 airlines.

Aviation Picture Library

moved around using interlinking systems of automatic trains, escalators and moving walkways.

Security

At the same time, airports will have to continue to tighten up on security. Smuggled weapons, drugs, and other illegal items are just part of the problem. With increasing air traffic there is also the danger that diseases and insect pests may be transported from country to country.

Tomorrow's passenger aircraft will bear little resemblance to those in service now. Some will be capable of climbing steeply to the edge of space and cruising at speeds of between 25,000 and 38,000 km/h. This would enable, say, a business executive to fly from London to Tokyo in the morning, attend a meeting there in the afternoon and return to London the same evening.

Less swift, but with greater capacity would be a large amphibious plane. Designed to alight or take-off from land or water it could use any small city-centre airport bordering on an ocean, lake or river. Powered by an atomic fusion engine, it would be able to transport 1,000 passengers and more than 135,000 kg of cargo at a cruising speed of 960 km/h.

Boarding bridges *adjust to aircraft in any parking position to protect passengers from weather, aircraft engine blast and dust.*

Jetway Systems

Seadromes

Coastal airports, or seadromes, built on long platforms jutting out into the sea, could become increasingly popular. In remote areas they would have the advantage of having no surrounding hills or buildings to obstruct airliners landing and relatively few people would be affected by their noise. Fast, pollution-free ground transport, like electric monorails,

TAKING ON FUEL

A jumbo jet uses as much as 8,000 litres of aviation fuel per hour when in flight. Its tanks may hold up to 100,000 litres of fuel weighing 50 tonnes – enough to keep a family car going for about 100 years. Between flights the aircraft is refuelled from tankers with a capacity of between 20,000 and 40,000 litres. High-speed pumps enable a Boeing 747 to have its tanks completely filled in about 20 minutes. The amount of fuel taken on board depends on the aircraft's load, the distance it has to travel and the forecast direction and speed of the winds.

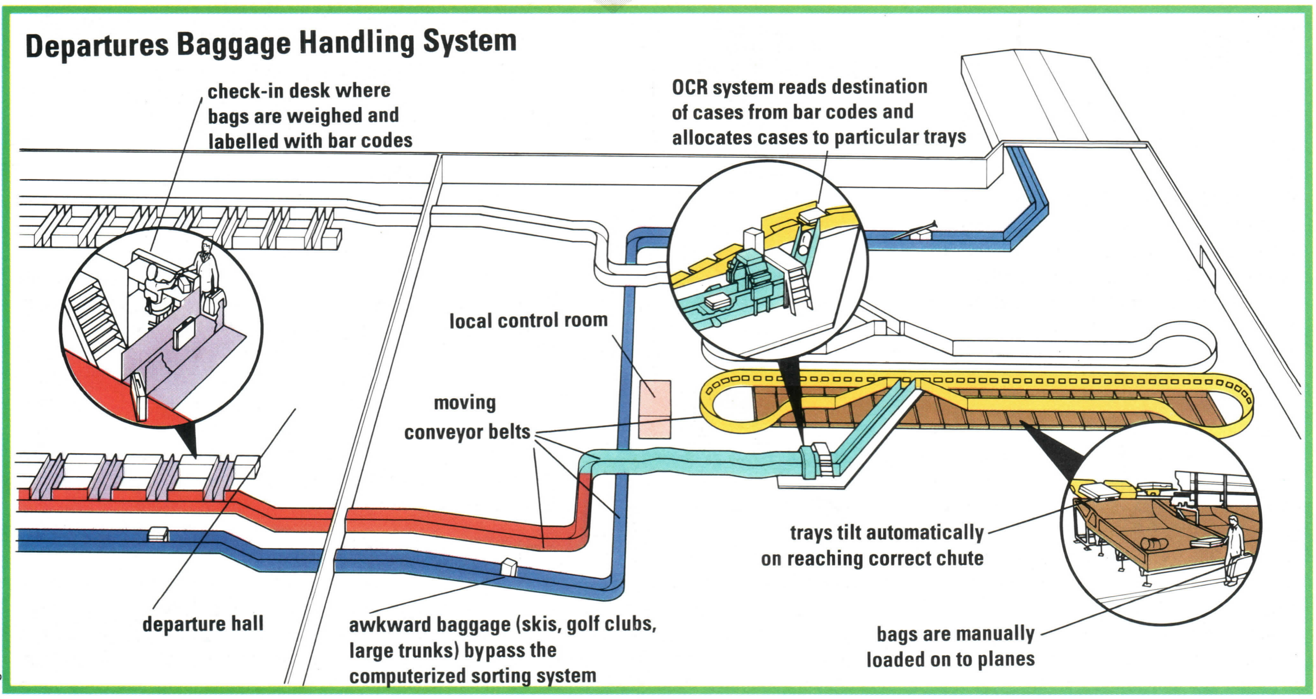
Automated baggage handling *in airports is speeding up a previously lengthy process. The optical character recognition system (below) sorts luggage at the rate of 60 bags per minute.*

Just amazing!

PLANE CRAZY

DALLAS FORT WORTH AIRPORT PLANS TO EXTEND TO HANDLE 150 MILLION PASSENGERS PER YEAR – ABOUT THE SAME AS THE POPULATION OF BRAZIL – FROM NINE RUN WAYS, 13 TERMINALS AND 260 GATES.

Paul Raymonde



Logan Fenamec/Mark Franklin

SEEING ATOMS   HEALING SUBMARINE   NANOCOMPUTER

MICRO ENGINEERING

The scanning probe microscope, *billionths of a centimetre above a surface, reveals details smaller than an atom.*

NANOTECHNOLOGY PROMISES a world of microscopic machines measured in nanometres – billionths of a metre. Built atom by atom, such devices could reproduce themselves to create a vast, unseen army of robot workers.

Ordinary microscopes cannot show detail that is smaller than the wavelength of light, or about one five-thousandth of a millimetre. But, by using a scanning probe microscope scientists can detect and record images of single atoms – opening up the possibility of nanotechnology.

All solids are covered with a fuzzy cloud of charged particles called electrons. In a scanning probe microscope, a tiny diamond needle is lowered to within a few billionths of a centimetre of the surface to be studied. This causes the electron clouds of the surface and needle to overlap and electrons can jump back and forth between them. The result is a minute electric current. As the needle scans the surface, it is raised and lowered by incredibly small amounts to keep the current constant. A 3D image is formed from a record of these up and down movements. In this way, detail smaller than the width of an atom has been observed.

Electron beam drill

Some of the latest types of microscope can be used not just to see things in fine detail, but to read and write information on an amazingly small scale. A scanning electron microscope works by bouncing beams of electrons off objects and measuring the way the beams are affected by the surface layer of atoms. The scanning

WA Technology Ltd

Just amazing!

NO ROOM FOR THE CUCKOO

IN 1988 FREDDY SUESS, A SWISS WATCHMAKER, CLAIMED TO HAVE THE WORLD'S SMALLEST PENDULUM CLOCK. MEASURING JUST 1CM TALL IT WEIGHS 1.5 GM ITS PENDULUM SWINGS 3 TIMES A SECOND!

Paul Raymonde